

Bionomic Observations of *Thereuonema tuberculata* (Scutigermorpha: Scutigerae) with New State Records from the USA¹

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Abstract *Thereuonema tuberculata* (Wood) (Scutigermorpha: Scutigerae) is an exotic centipede found in the eastern and midwestern United States. I present new records for this centipede in Nebraska and the first report from Kansas. Bionomics observations on the food preferences, behavior, and endoparasites of centipedes are discussed and compared with those previously described from its native range in Asia.

Key Words exotic species, Myriapod, captivity, gregarines

Centipedes are often perceived as indiscriminate predatory arthropods; however, the diet and biology of many species are very poorly documented with strong evidence that some species are opportunistic scavengers and will even feed on plant material (Lewis 1981). The diet of several Scutigermorpha includes both live prey and those that are scavenged (Yang et al. 2022) along with occasional plant material (Murakami 1956).

When centipedes are transported around the world both by accident and as parts of the pet trade, some become established in their new environments and can become invasive (Barber 2011, Reeves and Miller 2022). These centipedes have been established on continents far from their presumed origins and depending on their prey presumably could change the diversity of soil-dwelling organisms (Jonishi and Nakano 2020, Prado et al. 2018, Suehiro 1960). Several anthropophilic centipedes, such as *Cryptops hortensis* (Donovan), successfully established populations in North America after one or more introductions (Shelley 2002). *Thereuonema tuberculata* (Wood) (Scutigermorpha: Scutigerae) is established both inside buildings in the eastern United States and outdoors in the midwestern United States and was only recently reported (Reeves 2017, Reeves and Miller 2022). In Asia where it is native, *T. tuberculata* can range from tropical to subarctic habitats when nearby human structures allow them to overwinter and expand their ranges during the summer (Hirakizawa et al. 2023).

Many centipedes have successfully been kept in captivity as pets, in zoological displays, or as research organisms. Chiariello (2015) discussed the general husbandry

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and how observations on animal health can be made on captive centipedes. Observations on the basic biology of introduced Scutigermorpha (*Scutigera coleoptrata* (L.)) in captivity have a long history in North America (Marlatt 1902), and Murakami (1956) discussed observations on *T. tuberculata* in Japan. Herein, I discuss bionomics observations and new records for *T. tuberculata* collected in North America.

Materials and Methods

Centipedes were collected in Kansas and Nebraska. Live specimens were collected by hand and transferred to plastic jars with tissue paper for transport to the laboratory. All other specimens were killed in 70% isopropyl alcohol. Locations and habitats are described individually in results and discussion. All centipedes were morphologically identified and directly compared with preserved material reported by Reeves and Miller (2022). Voucher specimens of centipedes were deposited at the C. P. Gillette Museum of Arthropod Diversity at Colorado State University (Ft. Collins).

Throughout a 1.5-yr time span, three adult *T. tuberculata* were maintained in plastic 8-L terraria with sand, woody debris, and rocks. The substrate was chosen to resemble the environment found in Nebraska where this species was collected. Terraria had sealed lids to prevent escape of centipedes. Temperatures ranged from 18 to 22°C with a 12:12-h light schedule. Centipedes were fed by placing living or dead potential food directly into the terraria. Direct observations were made of hunting or scavenging either using ambient light during the day or with a red filtered light at night. If food was not consumed within 48 h, it was removed. Opportunistic observations of other behaviors such as self-grooming was recorded ad hoc.

Five adult centipedes from York Co., NE, were hand collected alive on 24 August 2022 and transported alive to the laboratory. Individually, these centipedes were chilled in a freezer for ~10 min. Centipedes were placed on glass slides and were killed by cutting the head off and then the digestive tract was carefully removed, along with the terminal abdominal segments, by using sharpened needles. Their alimentary canals were dissected in phosphate-buffered saline. Initially, fresh slides were observed at 40× magnification for obvious parasites. Next, all slides were fixed and stained with Diff-Quik, a modified Wright–Giemsa stain, following protocols described by Silverman and Frable (1990). Stained slides were examined microscopically at 40×, 100×, and 200× magnifications with an AmScope 40×–1600× binocular biological compound microscope. Both fresh and stained parasites were compared with images and descriptions of gregarines presented by Devetak et al. (2019).

Results and Discussion

New county and state collection records for *T. tuberculata* were discovered in Nebraska and Kansas. Previous records from North America were reported by Reeves (2017) and Reeves and Miller (2022).

Kansas: Riley Co., 22 September 2022, Kansas River along the riverbank in Manhattan, under rocks, adults and immatures.

Nebraska: Hall Co., 3 June 2022, Grand Island adjacent to Platte River, under rocks and wooden pallets, adults and exuviae. Keith Co., 12 October 2022, Lake McConaughy shoreline, under rocks, adults. York Co., 2 June 2022, Recharge Lake Park, under rocks, 24 August 2022, Recharge Lake Park, both adult and immatures with 5 pairs of legs.

Centipedes were found under rocks in both Kansas and Nebraska during the day. No more than two were found under the same rock. When exposed to sunlight, they rushed away under other debris. In Nebraska, centipedes were found in the same general proximity to *Armadillium vulgare* (Latreille), a terrestrial isopod, unidentified ants, and spiders. The rocks occasionally had relatively intact centipedes exuviae under them. Molting and leaving intact exuviae was observed in captivity, whereas consumption of exuviae after molting in captivity was reported by Murakami (1956).

In captivity, all centipedes exhibited thigmotactic behavior when exposed to sunlight or white light. They spent the majority of the day pressed under rocks or woody debris in the terraria. No foraging occurred during daylight, even when food was presented near their refuge. When observed at night while using a red filtered light, centipedes patrolled the terraria and were most active when arthropod prey was present.

When encountering small moths, the centipede used its legs to grab and entangle or grapple insects before biting them. When presented with *Euxoa auxiliaris* (Chozau), a moth as large as the centipede, an adult centipede used all of its legs to pull the moth to the ground and then under a rock. For smaller food items, centipedes pulled it back under a rock or wood for consumption.

Some food items were ignored even when offered more than once (Table 1), possibly indicating aversion or a lack of interest. Both injured and intact isopods, *A. vulgare*, were ignored. These terrestrial isopods were frequently found under the same rocks as the centipedes in the wild. Several nonnative earthworms, *Aporrectodea tuberculata* (Eisen), were offered as food. In every case, the worms were killed by cutting them into pieces before providing them. Centipedes most frequently ignored the worms; however, in one instance a worm was eaten and the centipede died within 24 h. Portions of this same earthworm were also fed to another species of centipede, *Lithobius forficatus* (L.), in captivity, with no mortality. When presented with the opportunity to eat some venomous or predatory arthropods, such as honey bees, ambush bugs, and lithobiomorph centipedes, these food items were ignored. Murakami (1956) observed *T. tuberculata* eating lithobiomorph centipedes in the wild. Other predatory arthropods, such as spiders and ants, were eaten. Lewis (1981) reported consumption of plant materials by centipedes in general, and Murakami (1956) stated that rice was consumed in the wild by *T. tuberculata*. I did not observe any interest in boiled rice.

Based on parasitological examination postdissection, one centipede collected on 24 August 2022 at Recharge Lake Park in Nebraska harbored gregarine parasites morphologically similar to *Trichorhynchus pulcher* (Boulenger) (Apicomplexa: Trichorhynchidae) based on comparison with those photographed by Devetak et al. (2019). *Trichorhynchus pulcher* is an obligate parasite of scutigero-morph centipedes, including *Scutigera coleoptrata* (L.), *Thereuopoda clunifera* Wood, and *T. tuberculata* (Devetak et al. 2019). Some gregarines with a wide range of hosts provide competitive advantage when some hosts species suffer asymmetric species specific pathology (Cominsky and Wesson 1997), which has not been tested in centipedes.

Table 1. Potential food items presented to *Thereuonema tuberculata* in captivity.

Potential Food Presented	Consumed (Additional Notes)
Cooked rice	No
Uncooked pork shavings	Yes
Coagulated chicken blood	Yes
Molted exuviae	No
Agelenidae (Arachnida), both living and injured	Yes
<i>Anechura bipunctata</i> (Dermaptera: Forficulidae), both living and injured	Yes
<i>Aporrectodea tuberculata</i> (Oligochaeta: Lumbricidae), cut into pieces	Yes (centipede died within 24 h)
<i>Apis mellifera</i> (Hymenoptera: Apidae), both living and injured	No
<i>Armadillidium vulgare</i> (Isopoda: Armadillidae), both living and injured	No
<i>Culex tarsalis</i> (Diptera: Culicidae), injured	Yes
<i>Eristalis</i> sp. (Diptera: Syrphidae), injured	Yes
<i>Euxoa auxiliaris</i> (Lepidoptera: Noctuidae), both living and injured	Yes
<i>Formica</i> sp. (Hymenoptera: Formicidae), dead	Yes
Halictidae (Hymenoptera), unidentified injured male	Yes
<i>Harmonia axyridis</i> (Coleoptera: Coccinellidae), puparia	Yes
<i>Lithobius forficatus</i> (Lithobiomorpha: Lithobiidae), both living and injured	No
<i>Melanoplus bivittatus</i> (Orthoptera: Acrididae), both living and injured	Yes (chewed a hole in the grasshopper abdomen)

Table 1. Continued.

Potential Food Presented	Consumed (Additional Notes)
Mutillidae (Hymenoptera), unidentified injured male	Yes
<i>Phymata americana</i> (Hemiptera: Reduviidae), both living and injured	No
<i>Popillia japonica</i> (Coleoptera: Scarabidae), injured	Yes (chewed a hole in the beetle abdomen)
Pyralidae (Lepidoptera), unidentified both living and injured	Yes
<i>Thereuonema tuberculata</i> (Scutigromorpha: Scutigridae), living	Yes (centipedes cannibalized each other when molting)
<i>Tipula paludosa</i> (Diptera: Tipulidae), both living and injured	Yes

The range of *T. tuberculata* in North America is still unknown with only limited published observations. The origin or origins of wild populations remain unknown, and ecological impacts of this species have yet to be determined. Based on my observations, this centipede feeds on a wide range of native and introduced prey and harbors at least one protozoa known to be parasitic in other centipedes.

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